Shaw's System of Testing Gases.

BY R. M. HASELTINE.

Mr. President and Gentlemen of the Institute:

This is the 21st meeting of the Ohio Institute of Mining Engineers, at many of which I have had the honor and the pleasure of appearing before you in various positions; and on this occasion I congratulate you on the brilliant prospects for its future. I believe the Institute is doing a noble work in the aid and encouragement it is giving to those who are trying to improve themselves in the arts of mining, and still further, in improving ourselves. Many improvements have been made in the last decade in and about the mines of our State and there is still

great room for further improvement. The operation of mines is one that is attended with many dangers through the various stages of its existence; and when we as individuals or as an Institute attempt to improve on any of the methods in use, we are forced to look beyond the limits of our own State in order to learn what our fellow crafts-men have accomplished in this or that particular, and what they had to contend with in the several mining districts, and how these difficulties have to be overcome from time to time. We note what new methods they have placed at our disposal and what new inventions they have made to render aid in performing any part of our work. My object in presenting this paper for your discussion at this meeting is with a view, if possible, to lessen the number of mine accidents and improve the sanitary condition of those employed in the mines. While the statistics show that in our own State during the last two years we have mined more coal to the life lost or the person seriously injured than ever before in its history, or of any of our sister States or Great Britian. And it is my ambition to maintain this high plane as long as I have the honor of fulfilling the duties of the Chief Inspector of Mines of the State. During my experience of over twenty years of active work in the mines as a mining engineer and operator, followed by my duties as Chief Inspector of Mines, I have frequently noticed a great want of an instrument or ready means which I hoped would some day be provided by which we could tell the condition of the air in the mines, in order that we could surely and quickly detect the presence of the invisible enemy of all miners in the presence of a slight per cent. of C H_4, fire damp, or C O_2, black damp, as it is encountered in our mines. The former is periodically hurling many of our fellow crafts-men to an untimely grave. The latter lurks in all poorly ventilated portions of the mine sending hundreds to a consumptive's grave. To remedy this as far as possible, I hold it our duty, as mining engineers, does not end with the simple duty of excavating the coal from the mine, but that we should do all in our power to protect the miners and the operators against all dangers of both life and property. Of the 825 mines of the State but 25 of those now in operation have ever shown the presence of carburetted hydrogen gas. We have no guarantee that this state of affairs will always continue, as the gas wells of the State show that large reservoirs exist under high pressure. This gas (C H_4) forms an ignitable mixture when mixed with from 6 to 6½ per cent. of air; and its presence is only known when we excavate into the porous measures whereby it is liberated.

The next most common element of danger encountered in the mines, is carbonic acid gas, or black damp as it is usually

known among the miners. It is almost certainly caused by an insufficient supply of fresh air and in our State is the most common of the two gases, and does great damage to the health of those employed in the mines though not in a violent manner. It has been found by experiments made on the other side of the water, that pure air carries 4–10 of a foot of C O2 to 1000 feet of air. This has been found true of the pure air of the mountains or in mid-ocean. The authorities place the permissible amount for health at 6 -10 of a cubit foot.

In the face of this fact I feel that you will agree with me that it would be injurious to the miner in the highest degree to permit the air of any working place to carry tenfold the permissable amount. I am informed by a reliable party that this excess has been found to exist in mines in a sister State, which must act as slow and steady poison. As both the gases so far treated in this paper can be diluted and expelled by ample currents of fresh air, it is our duty as mining engineers to pay strict attention to this simple and efficient remedy. The one great difficulty heretofore in determining the true character of the air in the mines, has been the want of some accurate and expeditious method of determining it in some positive manner. By the Shaw instrument which I will exhibit to you I have upon trial discovered that the lamp test heretofore relied upon to detect the presence of fire damp to be unreliable; and it is a fact susceptible of proof that it is possible to have within 50 per cent. of the ignitible line of gas present and the lamp shows no evidence of its presence that could be relied upon. Can it be that this defect in the lamp is one of the prime causes of permitting the accumulation of explosive gases in the mines, attended with its horrible results? If this fact upon trial is proven before the Institute, we should as a duty to our crafts-men who daily encounter these deadly gases, and to the operator whose property is imperiled, condemn all uncertain tests and substitute that which proves upon test trial to be the most efficient. So long as disasters continue there is urgent need of improvement of some kind; and we as members of this Institute should devise some means ourselves to prevent if possible a repetition of the accidents, and carefully examine into all improvements that may in any manner lessen their number. The question arises here how far have we fulfilled the duty naturally expected of us in devising a means of protection against accidents? Are we not afflicted with that human failing (so common) of resting under a false security in the same light that we look upon death itself, and admitting that of an early demise of our neighbor, but never anticipating its near approach to our own household? I believe there is no more important matter that can be

brought to the attention of the members of the Institute than that which relates to the presence of dangerous and poisonous gases in our mines, in order to assist in the protection of our fellow crafts-men. It is very important for the proper security of persons in mines generating fire damp in large quantities to have some means of detecting the presence of two per cent. of gas in some certain manner, as that amount places the mixture 33 per cent. toward the igniting point. I have never seen a lamp sensitive enough to detect the presence of 4 per cent. of C H_4 in the air which is 66 per cent. toward the point of ignition; and a devise not competent to detect it is worthless as an Inspector's instrument. The danger of an explosion pales if the percentage of inflammable gas is kept 3 to 4 per cent. below the ignitable line which is placed at 6 per cent.; and an instrument that will accurately determine this will fill the one great want.

The instrument that I will exhibit to you this evening is the invention of a fellow crafts-man, Mr. Thomas Shaw, an eminent mining engineer of Philadelphia. For simplicity of operation and accuracy of results, I fully believe it has solved the great problem of not only weighing and measuring, but of accurately determining the character of the air in the mine and the exact percentage of gas and air it contains. The inventor has in use many important inventions in the way of special engineers appliances; but in this he has produced one of the most complete instruments which it has fallen to the lot of man to originate. The instrument I have for illustration to-night is the property of the State of Ohio, and belongs to the Department of the Inspector of Mines. It is my intention to retain it in the office at the State House as a standard of tests for the State of Ohio. When you have fully examined into its merits and capabilities, you will agree with me in the pride that I feel in the fact that our Institnte was the first body of engineers to whom the matter was fully presented. If, as I believe, this instrument should become the standard of tests throughout the mining world our Institute will look upon the advance ground we have taken in this matter as a red letter day in our history. The Inspector's instrument which I have here is a counterpart of the Shaw system of tests in connection with the mines.

The plan of equipping a mine I will attempt to describe by the aid of a diagram prepared at my request by Mr. Shaw for this meeting in which only the principal operations are given as in all its detail it would occupy more time than is usually allotted to the reading of a paper on any subject. The foundation and one of the principal features of Mr. Shaw's discovery and invention was the now proven fact that a sharp line of demarcation

exists between the ignitable and non-ignitable mixtures of gas and air and that this line as proven by Mr. Shaw to exist in the narrow limits of the 1000 part, which fact seems almost miraculous that any compound of gases such as are found in explosive mixtures should submit to instrumental control in all proportions with the high degree of accuracy shown in test trial.

I will not attempt to go into all the details of the many useful features of Mr. Shaw's mine machine and signal system for protection of miners but will by the aid of this diagram show all of the salient points of value and endeavor to explain the mode of operation.

On observing the diagram it will be noticed that one of the first important acts is the removal of a large portion of the dangerous gases which is accomplished in this manner. A vacuum is maintained in a tank of cylinder shape some ten feet long by two feet in diameter, this vacuum is produced by a steam ejector sustaining a partial vacuum of even ten pounds. A 1-4 iron or steele tube is connected with this vacuum chamber and runs through the man way and gangways to the workings where dangerous gases are supposed to exist. The lower end is provided with a rubber tube twenty to thirty feet long with a metal cone shaped inlet in the extreme end. The air or gases in the mine chamber rush up the tube to the vacuum chamber from which point the gases are ejected to the outer air by the ejector referred to, marked 12 on the diagram. Mr. Shaw states that he has tested these tubes for quantity and that an average of 900 cubic feet is ejected per 24 hours for each tube, and since 10 cubic feet of gas is sufficient to produce a disaster the value of removing 9000 cubic feet (where the ordinary ventilation often fails to remove the accumulated gases) can not be doubted and I wish to say at this point that Mr. Shaw does not claim any invention in conducting gases from mines in pipes etc. as gases have been removed in this manner for over thirty years. All that I have shown on this diagram has reference to the removal of dangerous gases, but I now desire to call your attention to the very important fact that whilst these gases are being removed samples of gas are captured from the tube from time to time by an automatic pump (7) and delivered to Shaw's tester (9) where all the gases are tested automatically and dangerous mixtures of fire damp are at once reported by an audible sound long before the explosion line is reached. The diagram for sake of greater simplicity shows only one pipe running to the mine, while in point of fact several tubes are connected with the same and all connected with a rotating disc valve (8) that rotates one part at a time at each stroke of the pump (7) the

valve being automatically connected with said pump. The pipe (C) is connected with one of these parts and all the different tubes are thus connected around the circle of the valve. The valve remains stationary during the up stroke of the pump and is moved to a new position on the down stroke and the arrow head shown indicates the number of pipe that is being tested by the down stroke of the pump and as this pump makes thirty strokes per minute, it is competent to make that many tests in that period of time.

The next important provision in the system is connecting high pressure air with the vacuum tube in order to quickly reverse the currents when occasion requires the same, which is arranged in this manner: a duplex air pump is located on diagram (19) and is connected with a storage reservoir (14) and connected with pipes (11) with hand valve (7) where it is brought in direct contact with the pipe running from the mine and on depressing the key of valve shown high pressure air rush down the mines and blows a whistle in mine chamber (10) or the whistle can be silent by removal of cone or lid and a steady supply of fresh air will flow down the pipe under a pressure of eighty to one hundred pounds per square inch which is sufficient to supply twenty men with fresh air, in case the regular supply of air is cut off by a fall or otherwise.

The whistle signal is certainly important in any emergency that may arise requiring to signal to the miner for any purpose and becomes a red flag signal in case of accident, while the advantages of the independent air supply can only be fully realized in time of accident when this serves to be a God send to any miner dependent upon the same. In view of my having consumed more time than I at first anticipated, I will now only mention in a generral way that an ingenious code of signals is provided, a copy of which I have here for examination, that the signaling is done by the whistle or by the sound carrying properties of the pipe. The whistle can be blown in the mine one mile distant in one minute whilst the sound carrying property of the metal pipe carry the sound of taps on the tuning-fork shown in diagram, at the rate of three miles in one second. The code of signals can be learned by any party who can read in a few moments time. I will give you a few examples of the same and how the signals are readily converted into different languages, enabling all important communications to be carried on with a party in a foreign language by a party not acquainted with the language which sounds perhaps foolish and difficult until explained. There is so much of interest in this code of signals and the importance of the same that I could consume all

the evening on this part of my paper but the time requires me to omit much of the minor details.

Referring to the diagram again I will now call your attention to a simple and inexpensive expedient that costs a mere trifle but one that would have saved from time to time many hundreds of lives from one of those slow and terrible deaths that occur to imprisoned miners. The first great physical want of an imprisoned miner is a supply of fresh air, for no man can live five minutes without it, and I have explained to you how this want has been supplied. The next great want of the imprisoned miner is water to drink, and this is the inexpensive feature I referred to shown at (5) by this simple additional expedient liquid food can be furnished miners imprisoned in the mines. There is so much to be said on this subject that I feel myself constrained in my endeavors to cut short features of this kind. Returning again to the diagram I will now explain that the miner can send a whistle sound upward by pinching the rubber tube to his workings which causes a higher vacuum in the pipe which draws down a diaphram by opening a valve part to high pressure air and thus blows the whistle (2). I have witnessed this plant in a large mine in a sister State which generates large quantities of gas where it has been in successful operation for over eleven months, and I believe that it has come to stay, that it is practical, and that it is a life guard over the miners and the mines and when fully inaugurated that it will be the means of saving many lives in the future and a large amount of property and I think it should be thoroughly examined by all parties interested in mines and mining.

I will now put in operation one of Mr. Shaw's mine inspectors instruments which is designed for the express purpose of determining the amount of gas present in the air of the mine. The large cylinder is arranged to pump fresh air from the room while the small one is designed to pump gas from the bag containing an unknown mixture. The small pump is attached to the arm of the pump in such a manner that it can be readily moved to any place on the arm. This arm is graduated similarly to the limb of a transit. I will first establish a standard line by the use of the illuminating gas used in the city. This is done to establish a base to work from and stands in his case as the zero on a thermometer or as used on the limb of a transit. The deviation from the line at which the explosion of the standard rings the gong and the ringing line of the unkown mixture will represent the percentage of explosive gas in the mixture to be tested. This is readily determined by the graduations on the arm. The line of testing mixtures of gas hereafter will be indicated by the position of the small cylinder on the arm of the

pump; the number of graduations on the limb will indicate the per cent. or fraction thereof of gas contained in the mixture which is under examination. When this has been accomplished the accuracy can be proven by reversing the instrument and pumping a bag containing the same percentage of pure carburetted hydrogen gas mixed with pure air; by again reversing the instrument it can be re-tested and if the compound explodes at the same point as the first mixture the proof is made positive. In making the trial you will observe that the line of ignition of illuminating gas here is 7 per cent. and that at 6½ per cent. the gong will not ring, while at 7½ per cent. it rings loudly. This gas drawn the line one-half of one per cent. and this line can be followed down to the 1,000 part. It will be observed that by testing bags of mixtures the line of ignition is most positive as the chamber advances, also that it recedes with equal rapidity as it moves below the line of ignition, clearly indicating each half of one per cent. as the chamber is moved along the arm of the pump.

I will now test the sensitiveness of the safety lamp by placing it inside of this glass jar, first pumping 3 per cent. of gas into the chamber at the top and forcing it down through the gauze. I will increase the percentage by one per cent. at a time until there is a cap on the flame. It will be observed that the lamp shows no signs of the presence of gas until it reaches the line of ignition when it explodes within the gauze and is extinguished. I will now inject 4 per cent. of C. O.2 (black damp) into this mixture with a view of determining as to the percentage the mixture will be reduced below the line of ignition. It will be observed on test trial the presence of 4 per cent. of black damp does not affect the line of ignition any perceptible amount. As over 230 tests can be made with this instrument and the hour is growing late I will close in order that all who desire to come forward and inspect the instrument may have an opportunity for so doing.

The Massillon *Independent* in speaking of the paper uses the following language:

"Mr. Haseltine then exhibited the practical workings with new apparatus manufactured for the State of Ohio. He made the claim that the Shaw system would detect fire damp to the one-thousandth part, while the Davy lamp would do so only when it was present in igniting quantities. The members gathered closer as the comparative tests were made, and while some were converted, others kept their trust in the old Davy. The Shaw system embodies also a signal code from the mine work-

ings to the surface, by which a fairly extensive conversation may be carried on, and a contrivance by which air and liquid food may be sent to portions of the workings where an accident has taken place."

The Institute then adjourned until 8 o'clock A. M., to meet at the W. & L. E. depot.

FRIDAY MORNING, June 13th, 1890.

The members of the Institute accompanied by the young gentlemen of the graduating class of the High School and several others boarded a train provided for the occasion on the W. & L. E. R. R. and proceeded to the mines of the Howell Coal Co. on the Anderson farm. A number went into the mine while others examined objects of interest on the outside. When all had been examined that was of interest they again boarded the train and returned to the Pocock mine on the Hemperly farm where they alighted and spent an hour examining the various points of interest. The next halt was made at the Warwick and Keller mine on the Lutz farm where a tour of inspection was made, when the party returned to the train arriving at Massillon at one o'clock, all expressing themselves as being greatly pleased with what they had seen.

At half past two the members convened in the Opera House. On being called to order the Secretary read the following list of applicants for membership: H. D. Marble, Coal Operator, Cleveland; E. L. Jones, Mine Boss, Mineral Point; Geo. Atherton, Mine Sup't, Dillonville; Matthew English, Mine Sup't, Justus; Evan J. Evans, Coal Operator, Justus; J. A. Ede, Mining Engineer, Jackson; Leslie C. Turley, Fire Brick Manufacturer, Portsmouth; Wm. B. Rennie, Coal Operator, New Philadelphia; Roger Ashton, Mine Sup't, Bridgeport; E. D. Wileman, Civil and Mining Engineer, Massillon; Wm. Hibbs, Mining Engineer, Linton; John T. Phillips, Mine Boss, Krumroy; Joseph Collier, Mine Sup't, Massillon. On motion of Vice President, W. B. Hanlon, the Secretary was instructed to cast the vote of the Institute which was done, resulting in their election.

The author being absent, by request President Howells read a paper by Andrew Roy on Certificated Mine Inspectors. The members were anxious to discuss Mr. Roy's paper but felt delicate in doing so in his absence. On motion of Mr. Robert Bell all discussion on the paper was postponed until the winter meeting of the Institute after which Capt. J. L. Morris moved that a vote of thanks be extended to Mr. Roy for his able paper. Mr. Robert Bell and several others objected to a vote of thanks being tendered a party writing a paper and not being present to discuss its merits. The motion was put by the President and carried.